manufactures of filters, filter paper, and glass fiber; DOE officials and contractors; and representatives from academia.

After an extended discussion about potential laboratory methods for determining age limits, the participants concluded that no established accelerated aging tests could be used to establish HEPA filter lifetimes. The aging process of glass fibers cannot be separately determined from the aging of the glass fiber medium because of the effect of the binder, water repellency, and other treatments. The consensus from the 1997 meeting was that the only currently reliable experimental method for establishing age limits is to conduct selected criteria tests on field-aged HEPA filters. Unfortunately, this approach can only offer limited success because the broad range of variability in manufacturing quality will mask the effects of aging.

Nondestructive tests cannot measure filter deterioration caused by age. The annual in-place filter leak tests do not provide assurance that age-deteriorated HEPA filters will perform during high-stress accident conditions Johnson et al. showed that even several aged and weakened filters may not suffer from a loss of filter efficiency.[35]

8.9 Review of In-Place Filter Testing at Selected DOE Sites

In 1992 and 1993, LANL performed a two-year review of the large HEPA filtration systems at seven different DOE sites, including:

- Paducah Gaseous Diffusion Plant
- Portsmouth Gaseous Diffusion Plant
- LANL, Area 200 of FP4, Technical Area 55
- Plutonium Fuel Fabrication Facility and Plutonium Experiment Facility at SRS
- High Flux Beam reactor and Medical Research Reactor at Brookhaven National Laboratory
- Buildings 38 and 50 at Mound Plant (Mound)
- ORNL, High Flux Isotope Reactor, Radiochemical Engineering Development Center and Isotope Enrichment Facility

Although significant differences between the sites were found, there were also several common issues. The observations were divided into four areas:

Policy Development. [Includes filter shelf life, filter service life, role of HEPA acceptance and in-place filter testing and system oversight.] The goal should be to provide a technical basis for setting maximum storage and service times after which filters must be discarded or replaced.

Testing Multi-stage Systems. [Includes overall system and individual stage testing.] Requirements in this area include clarification for the use of acceptance-testing filters, the need to test intermediate stages of multiple stage systems, appropriate requirements for testing filters used with gloveboxes, and the types and degree of administrative oversight and record-keeping necessary when HEPA filers are part of exhaust and air emission control systems.

Guidance on In-place Filter Testing and System Supervision. [Includes testing practices, test equipment maintenance and calibration, special concerns of older systems, measurement uncertainty, pass/fail decisions, frequency of routine testing, analysis and reporting of testing results, and technical support and training of testing personnel.]

Uncertainty in In-place Filter Testing Results. The issue of how such results are affected by measurement methods, system characteristics, and system abnormalities needs to be studied.

Two principal conclusions have emerged from these reviews. First, there is an immediate need to develop information on how filter mechanical integrity decreases with time, and to use this information to establish limits on filter service life. Second, there is a general need to ensure the validity of in-place filter testing results and to improve testing practices. A mathematical framework for describing the effects of abnormal system features on testing results is proposed as an aid in understanding the uncertainty in in-place filter testing results.[36]

8.10 HEPA FILTER VACUUM CLEANERS AND PORTABLE HEPA FILTRATION SYSTEMS

HEPA filtered vacuum cleaners (HEPA-Vacs) and Portable HEPA Filtration Systems (PHFS) are most commonly used to control friable particulate before it becomes airborne. They are also used to control airborne particles and liquids in and around work areas and to provide localized control of loose debris when work operations could potentially cause the spread of contamination. When used in the nuclear industry, the HEPA-Vacs are commonly referred to as nuclear or radiological vacuum cleaners.

8.10.1 DESCRIPTION OF RADIOLOGICAL VACUUM CLEANERS

Radiological vacuum cleaners are generally well-constructed and well-sealed devices with a HEPA filter on the exhaust. They are normally mounted on a cart with a comfortable handle and lockable and steerable wheels for portability and control during use. The power module consists of a blower powered by an electric motor and controlled by an onboard switch. The filter module consists of a positively mounted and sealed HEPA filter, protected by a prefilter. All units should have a positive plenum (tank)-to-vacuum head seal. Vacuums that have latches but provide a loose head-to-tank seal that depends on the vacuum force to provide a positive seal (i.e., many commercially available shop vacuums) should not be used.

Some vacuum cleaners are equipped with controllers that allow the worker to regulate the flow. This works well in providing negative ventilation in small glove bags. Using HEPA filtered vacuum cleaners can significantly improve how contamination is controlled.

An in-line HEPA filter can be installed in the suction hose to collect radioactive material before it reaches the vacuum cleaner. Fittings can be made to connect the vacuum cleaner hose to the HEPA filter. As debris is sucked into the hose, it is deposited on the in-line HEPA filter instead of the HEPA filter inside the vacuum cleaner. Temporary shielding should be installed around the in-line filter before operation, as the filter becomes highly radioactive.

If a large amount of debris will be collected, installation of a waste drum in the suction hose should be considered to ensure the debris collects in a waste drum and not the vacuum cleaner. Commercial systems are available, or one can be made by welding two pipes into a spare drum lid. As each drum is filled, the lid can be swapped to a new drum and a regular lid can be installed on the full drum. Personnel doses are reduced because the debris is collected directly into the waste drum instead of the vacuum cleaner.

Vacuum cleaners should be constructed of a material that is easily decontaminated without damage to components. Units that use silicone-based material to prevent leakage should not be used. All hose connections should provide positive seals and should be constructed of a material that will not be damaged by repeated use or rough handling.

HEPA filters should have a positive seal and pass in-place leak testing. The filter hold-down clamps should provide the required force (20 lb/in.^{2}) to seal the filter and prevent dislodging during rough handling and repeated use. They should be constructed of a material that will not wrap or bend with repeated use.

The HEPA filter replacement method should be simple and should performable in minimum time to reduce exposure and the chance of radioactive contamination. The vacuum cleaners should be designed to ensure HEPA filter integrity under all conditions of use and to prevent unauthorized or accidental access to the inner surfaces of the vacuum. Units should be constructed with no sharp edges or burrs that could injure personnel or damage protective clothing.

HEPA filters used in HEPA-Vacs and PHFS should meet the efficiency and construction requirements for HEPA filters in DOE STD 3025[7] and ASME AG-1.[3] The maximum flow rate of the device should not exceed the flow rate at which the HEPA filter was efficiency tested. The HEPA filters should be certified at the ORFTF.

8.10.2 OPERATION

HEPA-Vacs and PHFS are used to clean up radioactive debris and provide negative ventilation in the work area. Improper use of HEPA-Vacs and PHFS may result in generation of airborne